AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions and listings of the claims in this application:

Claim 1. (Currently Amended) A digital signal processing apparatus for converting a first digital signal having a sampling frequency of fs (Hz) and a plurality of bits as quantization bits into a second digital signal having a sampling frequency of ~~m (m is a positive integer ≥ 2) X n (n is a positive integer ≥ 2) X fs (Hz) and one bit as a quantization bit~~ m x n x fs and one bit as a quantization bit wherein m and n are positive integers larger or equal to two, said digital signal processing apparatus comprising:

frequency analyzing means for subjecting said first digital signal inputted thereto to frequency analysis processing;

first noise level calculating means for calculating an average noise level of a predetermined range of said first digital signal based on a result of the frequency analysis obtained by said frequency analyzing means;

dither generating means for generating a dither signal of high frequencies beyond the audible range;

second noise level calculating means for calculating a noise level of the dither signal generated by said dither generating means;

normalizing means for normalizing the noise level calculated by said second noise level calculating means based on the average noise level calculated by said first noise level calculating means;

first oversampling means for oversampling said first digital signal at a sampling frequency of m (m is the positive integer $\geq$ 2) X fs (Hz);

adding means for adding the multi-bit digital signal oversampled by said first oversampling means to the dither signal having a noise level normalized by said normalizing means;

second oversampling means for oversampling an addition output of said adding means at a sampling frequency of n (n is the positive integer $\geq$ 2) X fs (Hz); and

$\Delta\Sigma$ delta-sum modulating means for converting a multi-bit digital signal oversampled by said second oversampling means into a 1-bit digital signal.

Claim 2. (Previously Presented) The digital signal processing apparatus as claimed in claim 1, wherein the dither signal generated by said dither generating means is sampled at a same sampling frequency as the sampling frequency of said first oversampling means.

Claim 3. (Previously Presented) The digital signal processing apparatus as claimed in claim 1, wherein a word length of the dither signal generated by said dither generating means is substantially equal to a word length of the multi-bit digital signal sampled by said first oversampling means.

Claim 4. (Previously Presented) The digital signal processing apparatus as claimed in claim 1, wherein said normalizing means comprises:

gain calculating means for calculating an equalizing coefficient for equalizing the noise level calculated by said second noise level calculating means with the average noise level calculated by said first noise level calculating means;

frequency characteristic limiting means for generating a filter coefficient for limiting a frequency characteristic of the dither signal from said dither generating means and subjecting the dither signal to frequency characteristic limiting processing using the filter coefficient; and

gain adjusting means for adjusting a noise level of an output from said frequency characteristic limiting means by using said equalizing coefficient from said gain calculating means.

Claim 5. (Previously Presented) The digital signal processing apparatus as claimed in claim 4, wherein said

frequency characteristic limiting means of said normalizing means generates a filter coefficient based on a band-pass filter characteristic, and subjects said dither signal to frequency characteristic limiting processing using the filter coefficient.

Claim 6. (Previously Presented) The digital signal processing apparatus as claimed in claim 5, wherein said frequency characteristic limiting means of said normalizing means further generates a 1/f filter coefficient based on a gradient filter characteristic having a gradient of 1/f (f is frequency) in addition to the filter coefficient based on said band-pass filter characteristic, and subjects said dither signal to frequency characteristic limiting processing using the two filter coefficients.

Claim 7. (Previously Presented) The digital signal processing apparatus as claimed in claim 6, wherein said frequency characteristic limiting means of said normalizing means subjects said dither signal to first frequency characteristic limiting processing using said 1/f filter coefficient, and then subjects an output of said frequency range limiting processing to second frequency characteristic limiting processing using said 1/f filter coefficient based on said band-pass filter characteristic.

Claim 8. (Previously Presented) The digital signal processing apparatus as claimed in claim 6, wherein said frequency characteristic limiting means of said normalizing means subjects said dither signal to frequency characteristic limiting processing using a combined filter coefficient obtained by combining said 1/f filter coefficient with said filter coefficient based on said band-pass filter characteristic.

Claim 9. (Previously Presented) The digital signal processing apparatus as claimed in claim 4, wherein said frequency characteristic limiting means of said normalizing means calculates a combined filter characteristic obtained by combining a band-pass filter characteristic with a 1/f filter characteristic, and subjects said dither signal to frequency characteristic limiting processing using the combined filter coefficient.

Claim 10. (Previously Presented) The digital signal processing apparatus as claimed in claim 4, wherein said frequency characteristic limiting means of said normalizing means comprises:

band-pass filter characteristic producing means for producing a band-pass filter characteristic;

frequency characteristic gradient calculating means for calculating a gradient of a frequency characteristic of said first digital signal based on the result of the frequency analysis obtained by said frequency analyzing means; and

a filter characteristic producing means for producing a filter characteristic based on the gradient calculated by said frequency characteristic gradient calculating means,

whereby said frequency characteristic limiting means of said normalizing means generates a filter coefficient obtained by combining the band-pass filter characteristic with the filter characteristic based on said gradient, and then subjects said dither signal to frequency characteristic limiting processing using the filter coefficient.

Claim 11. (Currently Amended) A digital signal processing method for converting a first digital signal having a sampling frequency of fs (Hz) and a plurality of bits as quantization bits into a second digital signal having a sampling frequency of ~~m (m is a positive integer ≥ 2) X n (n is a positive integer ≥ 2) X fs (Hz) and one bit as a quantization bit~~ m x n x fs and one bit as a quantization bit wherein m and n are positive integers larger or equal to two, said digital signal processing method comprising:

a frequency analyzing step for subjecting said first digital signal to frequency analysis processing;

a first noise level calculating step for calculating an average noise level of a predetermined range of said first digital signal based on a result of the frequency analysis obtained by said frequency analyzing step;

a second noise level calculating step for calculating a noise level of a dither signal generated by a dither generating means, wherein said dither signal is a signal of high frequencies beyond the audible range;

a normalizing step for normalizing the noise level calculated by said second noise level calculating step based on the average noise level calculated by said first noise level calculating step;

a first oversampling step for oversampling said first digital signal at a sampling frequency of m (m is the positive integer $\geq$ 2) X fs (Hz);

an adding step for adding the multi-bit digital signal oversampled by said first oversampling step to the dither signal having a noise level normalized by said normalizing step;

a second oversampling step for oversampling an addition output of said adding step at a sampling frequency of n (n is the positive integer $\geq$ 2) X fs (Hz); and

a ~~$\Delta\Sigma$~~ delta-sum modulating step for converting a multi-bit digital signal oversampled by said second oversampling step into a 1-bit digital signal.

Claim 12. (Currently Amended) A digital signal processing apparatus for converting a first digital signal having a sampling frequency of fs (Hz) and a plurality of bits as quantization bits into a second digital signal having a sampling frequency of ~~m (m is a positive integer ≥ 2) X n (n is a positive integer ≥ 2) X fs (Hz) and one bit as a quantization bit~~ m x n x fs and one bit as a quantization bit wherein m and n are positive integers larger or equal to two, said digital signal processing apparatus comprising:

frequency analyzing means for subjecting said first digital signal inputted thereto to frequency analysis processing;

first noise level calculating means for calculating an average noise level of a predetermined range of said first digital signal based on a result of the frequency analysis obtained by said frequency analyzing means;

spectrum generating means for generating a spectrum of a signal of high frequencies beyond the audible range based on the result of the frequency analysis obtained by said frequency analyzing means;

second noise level calculating means for calculating a noise level of the spectrum generated by said spectrum generating means;

normalizing and waveform synthesizing means for normalizing the noise level of the spectrum calculated by said second noise level calculating means based of the average noise level calculated by said first noise level calculating means and for synthesizing a temporal waveform signal based on the spectrum;

first oversampling means for oversampling said first digital signal at a sampling frequency of m (m is the positive integer $\geq$ 2) X fs (Hz);

adding means for adding the multi-bit digital signal oversampled by said first oversampling means to the signal of high frequencies beyond the audible range, the signal of high frequencies beyond the audible range having the noise level normalized by said normalizing and waveform synthesizing means and being synthesized into a waveform by said normalizing and waveform synthesizing means;

second oversampling means for oversampling an addition output of said adding means at a sampling frequency of n (n is the positive integer $\geq$ 2) X fs (Hz); and

$\Delta\Sigma$ delta-sum modulating means for converting a multi-bit digital signal oversampled by said second oversampling means into a 1-bit digital signal.

Claim 13. (Previously Presented) The digital signal processing apparatus as claimed in claim 12, wherein said spectrum generating means comprises:

spectrum calculating means for calculating a spectrum of a noise level in a predetermined range from the result of the frequency analysis obtained by said frequency analyzing means;

spectrum selecting means for selecting a spectrum line having a high noise level from the result of the frequency analysis and the spectrum calculated by said spectrum calculating means;

harmonic spectrum generating means for generating a harmonic spectrum of the spectrum line having the high noise level selected by said spectrum selecting means; and

spectrum adding means for adding a spectrum based on the harmonic spectrum generated by said harmonic spectrum generating means.

Claim 14. (Previously Presented) The digital signal processing apparatus as claimed in claim 12, wherein said normalizing and waveform synthesizing means comprises:

gain calculating means for calculating an equalizing coefficient for equalizing the noise level calculated by said second noise level calculating means with the average noise level calculated by said first noise level calculating means;

gain adjusting means for adjusting the noise level of the spectrum of the signal of high frequencies beyond the audible range from said spectrum generating means by using said equalizing coefficient calculated by said gain calculating means; and

waveform synthesizing means for generating a temporal waveform signal of said spectrum whose noise level is adjusted by said gain adjusting means.

Claim 15. (Previously Presented) The digital signal processing apparatus as claimed in claim 13, wherein said spectrum adding means comprises a first spectrum adding means and said spectrum generating means further comprises:

multiplying means for multiplying a spectrum of a signal of high frequencies beyond the audible range generated by a spectrum generating means of another channel by a controllable combining coefficient; and

second spectrum adding means for adding the spectrum from said first spectrum adding means to an output of said multiplying means and thereby generating a spectrum for

controlling a degree of separation between at least two channels.

Claim 16. (Previously Presented) The digital signal processing apparatus as claimed in claim 14, wherein said normalizing and waveform synthesizing means further comprises:

gradient filter characteristic producing means for producing a gradient filter characteristic having a gradient of 1/f (f is frequency); and

multiplying means for multiplying the spectrum from said spectrum generating means by said gradient filter characteristic and supplying an output of the multiplication to said gain adjusting means.

Claim 17. (Previously Presented) The digital signal processing apparatus as claimed in claim 14, wherein said normalizing and waveform synthesizing means further comprises:

frequency characteristic gradient calculating means for calculating a gradient of a frequency characteristic in a predetermined range of said first digital signal from the result of the frequency analysis obtained by said frequency analyzing means;

gradient characteristic producing means for producing a gradient characteristic based on the gradient calculated by said frequency characteristic gradient calculating means; and

multiplying means for multiplying the spectrum from said spectrum generating means by the gradient characteristic produced by said gradient characteristic producing means and supplying an output of the multiplication to said gain adjusting means.

Claim 18. (Previously Presented) The digital signal processing apparatus as claimed in claim 14, wherein said normalizing and waveform synthesizing means further comprises:

frequency characteristic gradient calculating means for calculating a gradient of a frequency characteristic in a predetermined range of said first digital signal from the result of the frequency analysis obtained by said frequency analyzing means;

gradient characteristic producing means for producing a gradient characteristic based on the gradient calculated by said frequency characteristic gradient calculating means;

flat characteristic generating means for generating a flat frequency characteristic;

third noise level calculating means for calculating a noise level of a predetermined range of said first digital signal based on the result of the frequency analysis obtained by said frequency analyzing means;

characteristic selecting means for selecting between the gradient characteristic from said gradient characteristic

producing means and the flat characteristic from said flat characteristic generating means based on the noise level calculated by said third noise level calculating means; and

multiplying means for multiplying the spectrum from said spectrum generating means by a characteristic selected by said characteristic selecting means and supplying an output of the multiplication to said gain adjusting means.

Claim 19. (Previously Presented) The digital signal processing apparatus as claimed in claim 14, wherein said normalizing and waveform synthesizing means further comprises:

frequency characteristic gradient calculating means for calculating a gradient of a frequency characteristic in a predetermined range of said first digital signal from the result of the frequency analysis obtained by said frequency analyzing means;

third noise level calculating means for calculating a noise level of a predetermined range of said first digital signal based on the result of the frequency analysis obtained by said frequency analyzing means;

gradient coefficient generating means for generating a gradient coefficient based on the noise level calculated by said noise level calculating means;

first multiplying means for multiplying the gradient of the frequency characteristic calculated by said frequency

characteristic gradient calculating means by the gradient coefficient generated by said gradient coefficient generating means;

gradient characteristic producing means for producing a gradient characteristic based on an output of the multiplication of said first multiplying means; and

second multiplying means for multiplying the spectrum from said spectrum generating means by the gradient characteristic produced by said gradient characteristic producing means and supplying an output of the multiplication to said gain adjusting means.

Claim 20. (Currently Amended) A digital signal processing method for converting a first digital signal having a sampling frequency of fs (Hz) and a plurality of bits as quantization bits into a second digital signal having a sampling frequency of ~~m (m is a positive integer ≥ 2) X n (n is a positive integer ≥ 2) X fs (Hz) and one bit as a quantization bit~~ m x n x fs and one bit as a quantization bit wherein m and n are positive integers larger or equal to two, said digital signal processing method comprising:

a frequency analyzing step for subjecting said inputted first digital signal to frequency analysis processing;

a first noise level calculating step for calculating an average noise level of a predetermined range of said first

digital signal based on a result of the frequency analysis obtained by said frequency analyzing step;

a spectrum generating step for generating a spectrum of a signal of high frequencies beyond the audible range based on the result of the frequency analysis obtained by said frequency analyzing step;

a second noise level calculating step for calculating a noise level of the spectrum generated by said spectrum generating step;

a normalizing and waveform synthesizing step for normalizing the noise level of the spectrum calculated by said second noise level calculating step based on the average noise level calculated by said first noise level calculating step and for synthesizing a temporal waveform signal based on the spectrum;

a first oversampling step for oversampling said first digital signal at a sampling frequency of m (m is the positive integer $\geq$ 2) X fs (Hz);

an adding step for adding the multi-bit digital signal oversampled by said first oversampling step to the signal of high frequencies beyond the audible range, the signal of high frequencies beyond the audible range having the noise level normalized by said normalizing and waveform synthesizing step and being synthesized into a waveform by said normalizing and waveform synthesizing step;

a second oversampling step for oversampling an addition output of said adding step at a sampling frequency of n (n is the positive integer ≥ 2) X fs (Hz); and

a ~~ΔΣ~~ delta-sum modulating step for converting a multi-bit digital signal oversampled by said second oversampling step into a 1-bit digital signal.

Claim 21. (Currently Amended) A digital signal processing apparatus for converting a first digital signal having a sampling frequency of fs (Hz) and a plurality of bits as quantization bits into a second digital signal having a sampling frequency of ~~m (m is a positive integer ≥ 2) X n (n is a positive integer ≥ 2) X fs (Hz) and one bit as a quantization bit~~ m x n x fs and one bit as a quantization bit wherein m and n are positive integers larger or equal to two, said digital signal processing apparatus comprising:

frequency analyzing means for subjecting said first digital signal inputted thereto to frequency analysis processing;

high-frequency signal generating means for generating a signal of high frequencies beyond an audible range based on a result of the frequency analysis obtained by said frequency analyzing means;

first oversampling means for oversampling said first digital signal at a sampling frequency of m (m is the positive integer ≥ 2) X fs (Hz);

adding means for adding the multi-bit digital signal oversampled by said first oversampling means to the signal of high frequencies generated by said high-frequency signal generating means;

second oversampling means for oversampling an addition output of said adding means at a sampling frequency of n (n is the positive integer ≥ 2) X fs (Hz); and

$\Delta\Sigma$ delta-sum modulating means for converting a multi-bit digital signal oversampled by said second oversampling means into a 1-bit digital signal.

Claim 22. (Previously Presented) The digital signal processing apparatus as claimed in claim 21, wherein said high-frequency signal generating means comprises:

spectrum copying means for copying a spectrum in a predetermined range of the result of the frequency analysis obtained by said frequency analyzing means and generating a spectrum portion for forming the signal of high frequencies beyond the audible range by using the copied spectrum for a plurality of blocks of the signal;

frequency characteristic gradient calculating means for calculating a gradient of a frequency characteristic of said first digital signal from the result of the frequency analysis obtained by said frequency analyzing means;

gain calculating means for calculating a gain to be provided to said spectrum portion for forming the signal of high frequencies beyond the audible range, from the gradient calculated by said frequency characteristic gradient calculating means;

gain adjusting means for adjusting a gain of said spectrum portion for forming the signal of high frequencies beyond the audible range based on the gain calculated by said gain calculating means;

spectrum adding means for adding said spectrum portion for forming the signal of high frequencies beyond the audible range, said spectrum portion being adjusted in gain by said gain adjusting means, to each frequency; and

a waveform synthesizing means for generating a temporal waveform signal as the signal of high frequencies beyond the audible range from the added spectrum from said spectrum adding means.

Claim 23. (Previously Presented) The digital signal processing apparatus as claimed in claim 21, wherein said high-frequency signal generating means comprises:

first noise level calculating means for calculating an average noise level of a predetermined range of said first digital signal based on the result of the frequency analysis obtained by said frequency analyzing means;

dither generating means for generating a dither signal, which is the signal of high frequencies beyond the audible range;

second noise level calculating means for calculating a noise level of the dither signal generated by said dither generating means; and

normalizing means for normalizing the noise level calculated by said second noise level calculating means based on the average noise level calculated by said first noise level calculating means.

Claim 24. (Previously Presented) The digital signal processing apparatus as claimed in claim 21, wherein said high-frequency signal generating means comprises:

first noise level calculating means for calculating an average noise level of a predetermined range of said first digital signal based on the result of the frequency analysis obtained by said frequency analyzing means;

spectrum generating means for generating a spectrum of the signal of high frequencies beyond the audible range based

on the result of the frequency analysis obtained by said frequency analyzing means;

second noise level calculating means for calculating a noise level of the spectrum generated by said spectrum generating means; and

normalizing and waveform synthesizing means for normalizing the noise level of the spectrum calculated by said second noise level calculating means based on the average noise level calculated by said first noise level calculating means and for synthesizing a temporal waveform signal based on the spectrum.

Claim 25. (Currently Amended) A digital signal processing method for converting a first digital signal having a sampling frequency of fs (Hz) and a plurality of bits as quantization bits into a second digital signal having a sampling frequency of ~~m (m is a positive integer ≥ 2) X n (n is a positive integer ≥ 2) X fs (Hz) and one bit as a quantization bit~~ m x n x fs and one bit as a quantization bit wherein m and n are positive integers larger or equal to two, said digital signal processing method comprising:

a frequency analyzing step for subjecting said first digital signal to frequency analysis processing;

a high-frequency signal generating step for generating a signal of high frequencies beyond the audible range based on

a result of the frequency analysis obtained by said frequency analyzing step;

a first oversampling step for oversampling said first digital signal at a sampling frequency of m (m is the positive integer ≥ 2) X fs (Hz);

an adding step for adding the multi-bit digital signal oversampled by said first oversampling step to the signal of high frequencies generated by said high-frequency signal generating step;

a second oversampling step for oversampling an addition output of said adding step at a sampling frequency of n (n is the positive integer ≥ 2) X fs (Hz); and

a $\Delta\Sigma$ <u>delta-sum</u> modulating step for converting a multi-bit digital signal oversampled by said second oversampling step into a 1-bit digital signal.